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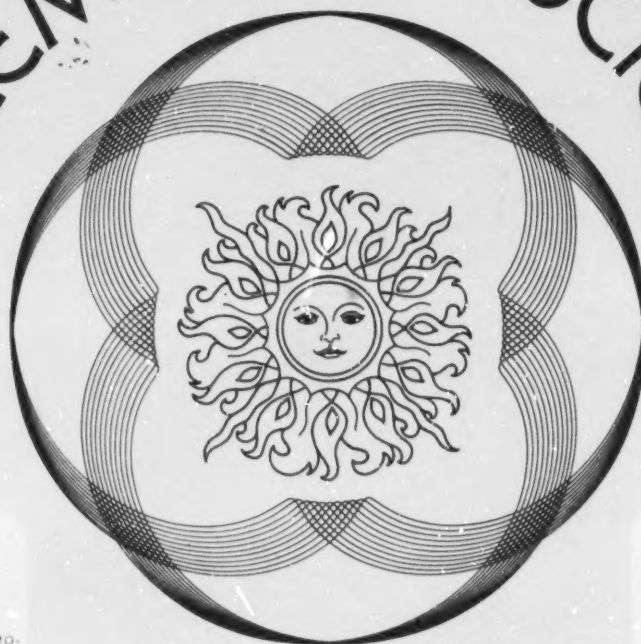
ABSTRACT

Elementary Science Study (ESS) units were examined by elementary teachers on a science writing team to identify energy education concepts within the existing curriculum in Minnesota. The outline of energy education concepts is given here along with some energy education science activities for elementary students. The activities are structured into a three-level sequence of lessons: exploration, labeling, and application. While some activities were written by team members, other activities have been adopted from ESS materials. (MR)

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ENERGY EDUCATION

IN ELEMENTARY SCIENCE



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Energy Education in Elementary Science

ESS* units were examined by elementary teachers on a science writing team to identify energy education concepts within the framework of the existing curriculum. An outline of energy education concepts developed by the Energy Task Force of the Minnesota Department of Education was followed and is included. Some units, such as Batteries and Bulbs are related to energy topics but do not deal with energy concepts directly.

The writing team identified the points of common ground in the units and the energy education concepts. Three matrices were developed around the separate topics of electricity, heat and light. These topics were used as organizers for presenting the energy education concepts. The team then identified on the matrices the subtopics to which Batteries and Bulbs and the other ESS units apply. Some units will be enriched if they are taught simultaneously or sequentially. For example, Heating and Cooling should be taught in conjunction with Ice Cubes to get the most out of each unit.

Some supplementary activities were developed by the writing team to extend the science units to energy education. These activities were structured into a three-level sequence of lessons: exploration, labeling, and application.

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The beginning lessons are called exploration. These lessons encourage creative experiences with the materials, and involve manipulation to determine some of the possible avenues of investigation. In some cases, an entire ESS unit may be viewed as an exploration. In others, a single lesson is the exploration. An exploration is a carefully orchestrated selection of materials and situations to encourage questioning, testing, creating, and probing. The teacher is able to predict, through the selection of materials, the types of questions likely to be raised by students. These questions and others raised by the teachers form the basis for extended investigations in the topic selected for study.

The type of activity which flows from exploration activities is called a labeling activity. As children have experiences in exploration, they are encouraged to verbalize about their experiences. The teacher reinforces their verbalization and gives the concept label for their experience. This phase provides for vocabulary building based on those experiences.

The next step in this learning cycle is application activities. These are activities which apply the concept in a new but related situation. They reinforce and extend the labeled concept. New application activities were generated to make a bridge between an existing science unit activity and the energy education concepts.

An example of the complete cycle of exploration, labeling, and application can be seen in the treatment of the concepts of heat. The ESS unit that contributes to this topic is Ice Cubes. The

entire unit was viewed by the writing team as a series of exploration lessons.

A concept labeling activity was written to label the concept "Insulation." Two new activities, "Winter Home," and "Summer Home," were developed to apply the concept.

OUTLINE OF ENERGY EDUCATION TOPICS

(Used as the basis for the analysis of the ESS program)

I. BASIC ENERGY INFORMATION

- A. Definition - Properties
- B. Sources - Renewable and non-renewable
- C. Forms: chemical, mechanical, radiant, nuclear, electrical
- D. Uses: residential, commercial, industrial (agriculture, food processing, mining, manufacturing), transportation, utility generation
- E. Conversion Systems/Technologies
- F. Ways of Conserving Energy

II. SOCIETY'S DEPENDENCE ON ENERGY

- A. Demands/needs related to resources (end-use) and life style
- B. Effects upon economy and economic system
- C. Effects on Political Relationships: local, national, international
- D. Values

III. POSSIBLE SOLUTIONS - PROBLEMS AND ADVANTAGES OF ENERGY ALTERNATIVES

- A. Alternative sources (types, uses, supply, time-lag) (values: cost, change in life style, trade-offs)
- B. Conservation (types, uses, supply, time-lag) (values: cost, change in life style, trade-offs)

IV. MINNESOTA'S ENERGY ISSUES

- A. Location, climate
- B. Sources available
- C. Problems with sources
- D. Ownership
- E. Control and effect of government policies and regulations
- F. Transportation
- G. Values

ENERGY CONCEPTS FOR ELEMENTARY EDUCATION*

Background Material for Teachers

DEFINITIONS

1. Energy is the capacity to do work or make something move. The "go" of things.
 - A. Power is the rate that energy is produced or used.
 - B. Efficiency is the amount of work done in proportion to the energy used.
 - C. Work is done when an object is moved.
 - D. Force is required to produce an acceleration in the motion of a body.
2. Energy is a resource.
3. Energy is the ability to cause change.

SOURCES: WHERE DOES ENERGY COME FROM?

1. Primary Sources

Primary sources are sources naturally available on the earth.

A. Renewable Sources are recurring or continuous.

1. The sun is the main source of energy.
2. Other renewable sources of energy are: geothermal, wind, hydro, tidal, and organic material.

Although they are available, the following sources are little used and need further development.

- a. Wind power
- b. Solar power
- c. Tides
- d. Geothermal
- e. Organic Wastes
- f. Peat (through some processes of recovery)

B. Non-renewable Sources are sources that take a great deal of time to form and cannot be replenished in human time spans.

1. Some non-renewable sources are fossil fuels: coal, oil, natural gas, and peat.
 - a. Currently most of our usable energy comes from fossil fuels.
 - b. Fossil fuels are non-renewable resources in limited supply.
 - c. No one knows exactly how much fossil fuel remains. Estimates depend on finding out where they are available, how easy it would be to recover them, and the cost of this recovery.
 - d. Some fossil fuels are in difficult places for recovery (e.g., oil, shale, tar sands, liquid natural gas and liquid petroleum gas.)

* From Energy Task Force, Minnesota Department of Education

2. Another non-renewable source is uranium used in nuclear fission reactors.

2. Secondary Sources

Secondary sources of energy are products of human technology.

- A. Electricity is a secondary source of energy. Primary sources of energy are used to make it.
- B. Some other secondary sources of energy are: solid wastes, fuel cells and the conversion of chemical energy.

3. Differences Among Energy Sources:

- A. Some work only under certain conditions or are practical only under certain conditions.
- B. Some work only in certain places.
- C. Some take much time to form.
- D. Some are slower and less efficient.
- E. Some take less time to convert.
- F. Some need technology to be converted to usable forms.

STATES

The basic states of energy are energy at rest and energy at work.

1. Kinetic energy is energy at work; the product of force and movement. (Examples: machines at work, persons at work, burning fuel.)
2. Stored or potential energy is energy at rest which can be made active. (Examples: nuclear energy, fossil fuels, a boulder on top of a hill, a battery, or water behind a dam.)

STORAGE

1. Potential energy is stored energy.
 - A. Fossil fuels are stored chemical energy and are made active by combustion.
 - B. Nuclear energy is stored energy in the atom.
2. Solar, tidal and geothermal energy are sources of energy flows; ways must be found to store them.

FORM: HOW CAN ENERGY BE SEEN AND FELT?

1. Energy can take many forms.
 - A. Energy can be detected in the following forms: heat, light, motion.
 - B. Energy can take the following forms: thermal, radiant, chemical, mechanical, sound and nuclear.
2. Energy can be measured (e.g., temperature measurement, measuring the change of position, reading meters such as gas meters, ohm meters, and volt meters).

ENERGY CONVERSION: WHERE DOES ENERGY GO?

1. Energy can be converted from one form to another.
2. Once energy is used, it cannot be used again in that form. (Note: This is a beginning level for the understanding that energy is neither created nor destroyed.)
3. In changing energy from one form to another, some energy is lost.
4. As energy is used, it produces by-products (such as heat) which may be recycled or which may be unavailable for us.

ENERGY TRANSFER

Energy is transferred by convection, radiation and conduction.

TRANSPORTATION OF ENERGY

Energy sources are transported by pipe or pipeline, radiation, ship or barge, wire or line, truck and train.

HOW IS ENERGY USED?

BASIC USES

1. Energy is needed to do work and to live.
2. Nothing acts, nothing moves without energy.
3. Energy drives the muscles of human beings.
4. Machines use energy to make things.
 - A. Some machines are more efficient than others.
5. Machines use energy to change energy from one form to another (e.g., chemical to mechanical).
6. Machines use energy to change potential energy to kinetic energy.
7. Energy must be spent to get energy we can use.
8. Energy is used in our daily living to make our clothes, food, paper, and to move us from place to place in cars and buses.

PERSONAL/SOCIAL USES

1. As individuals we are personally dependent upon energy.
2. Individuals and groups have responsibility for energy conservation and use.
3. Energy can be conserved by developing energy saving habits.
4. Societal actions and values extend or exhaust available supplies of energy.

- A. Past and present use of energy resources precipitated and accelerated the energy problem.
 - B. In order to impact on the energy problem, old habits must be changed.
5. Population changes directly influence energy use, availability and supply.

NATIONAL USES

1. Industry

Industry uses much of our country's energy.

- A. About forty percent of all energy is used by industry.
- B. Industry uses energy for heating, electricity, running machinery, electrolytic processes, processing raw materials, and maintaining a plant or office.
- C. The following industries are high users of energy: food processing, oil pumping and refining, steel and aluminum manufacturing, paper manufacturing, glass/clay/stone products, and chemical industries.

2. Transportation

Energy is used for transportation.

- A. Transportation requires 25 percent of our country's energy.
- B. Automobiles account for more than half of the energy used for transportation.
- C. Trucks, airplanes, and trains also use energy.

3. Residential

Homes use energy for heating, cooling, lighting and appliance use.

- A. Twenty percent of the country's energy is used for residences.
- B. Homes use the highest amounts of energy for heating, water heating, refrigeration and cooking.

4. Commercial

Energy is used for commercial places such as offices, businesses, hotels, schools, hospitals and restaurants.

MINNESOTA USE

Minnesota's use of energy is different from the national picture.

- 1. Minnesota has limited non-renewable energy sources.
- 2. Minnesota depends upon energy sources from outside the state.
- 3. Minnesota has special problems of transmission and transportation of energy resources.
- 4. Minnesota has a long heating season requiring greater residential use of energy.
- 5. Minnesota has special problems with:

CONSERVATION

1. Consumption of fossil fuels has been increasing faster than the rise in population during the past 30 years. The demand will increase.
2. We must conserve the non-renewable fuels that are left.
3. Major energy users must become big energy savers.
4. Energy conservation buys time to develop new alternative sources.
5. Some ways that major energy savings can be practices are: Industry - building design and industrial operating changes, recycling and increased energy transmission efficiency; Transportation - mass transit and use of smaller automobiles; Residential - use of more efficient appliances, recycling and improved home insulation.
6. People must identify, examine and clarify their own values and behave in a way that is consistent with those values.

WHAT ARE THE CONSEQUENCES OF ENERGY USE?

TRADE OFFS

1. Economic, ecological, aesthetic, political and social trade-offs are involved when decisions are made regarding the use of energy resources.
2. Energy-environment decisions require making value judgments of the trade-offs involved. A decision involves the acceptance of the possible disadvantages of the choice along with the advantages.
3. As we use up our non-renewable resources and have a hard time paying for foreign fuels, there will be more governmental action, voluntary conservation, market place restructuring or a combination of these.

ECONOMIC CONSEQUENCES

1. Supply

- A. We are consuming our energy sources faster than we are able to bring alternatives into practicality.
- B. New sources of energy must be identified and developed.
- C. U.S. oil and natural gas supplies will be depleted in about 100 years even if there is not an increase in our present rates of consumption.
- D. U.S. oil and gas production does not meet our nation's needs. Oil imports are increasing each year.
- E. Historically, there has been from three to five decades between the first speculation into new sources of energy and their commercial feasibility.

2. Cost

- A. As energy is used or conserved, there is a direct impact on economic systems.
- B. Future energy systems will demand extensive capital.
- C. High costs of new energy sources limit their use.

3. Cost/Supply Interaction

- A. Shortage of a material such as oil occurs when, at a given price, the demand exceeds the supply.
- B. Energy scarcity requires that growing economies make a vastly larger capital investment and/or reduce their energy demands.

ENVIRONMENTAL CONSEQUENCES

- 1. As energy is used or conserved, there is a direct impact on our environment.
- 2. Energy production affects our surroundings.
- 3. Sources of energy that we use differ in their environmental effects.
- 4. A concern for the environmental consequences of energy use may require additional energy and also may demand additional money.

LIFE STYLE CONSEQUENCES

- 1. The relationship between energy sources, consumption and life styles must be examined.
 - A. Energy use has an impact on family economics.
 - B. Energy conservation has an impact on family life style.
- 2. Changes of energy use results in the creation of some jobs and the loss of others.
- 3. New or modified perceptions of living and working styles will be needed to deal with the energy problem.

POLITICAL CONSEQUENCES

- 1. The necessity to import oil influences U.S./foreign policies.
- 2. Environmental and economic effects of energy development and use affect relationships between people in regions of this country and the world.
- 3. If the energy problems reach a crisis stage, there will be more governmental action in the distribution and consumption of energy resources.
- 4. Our present energy practices will affect alternatives of societies in the future.

Energy Topic/ESS Unit Index

ENERGY TOPICS*	Energy Related Science Units										
	OPTICS	LIGHT & SHADOWS	DAYTIME ASTRONOMY	GROWING SEEDS	LIFE OF PEAS & BEANS	STARTING FROM SEEDS	HEATING & COOLING	ICE CUBES	BATTERIES & BULBS, 1	BATTERIES & BULBS, 3	BATTERIES & BULBS, 5
I. Basic Energy Information											
A. Sources	X	X	X								X
B. Definitions/Properties	X	X	X				X	X	X	X	X
C. Forms of Energy	light	light	light	light	light	light	heat	heat	elec.	elec.	elec.
D. Uses				X	X	X	X	X	X	X	X
E. Conversion Systems or Technology	X			X	X	X			X	X	X
F. Conservation								X			
II. Society's Dependence											
A. Demands/needs											
B. Economic Relationships											
C. Political Relationships											
D. Values											
III. Possible Solutions											
A. Alternative sources											
1. Types, uses, etc.											X
2. Values, cost, etc.											X
B. Conservation											
1. Types, uses, etc.											
2. Values, cost, etc.											
IV. Minnesota Energy Issues											
A. Location/climate											
B. Sources available											
C. Problems with sources											
D. Ownership											
E. Control/effect of government											
F. Transportation											
G. Values											

Lesson Sequences for ESS Energy Concepts

Energy Form	ESS Unit	Exploration	Concept Label	Application
Electricity	Batteries & Bulbs (Primary)	Kit	Electrical Energy *	Let's Use It *
Electricity	Batteries & Bulbs (Intermediate)	Red Devil *	Conversion *	Energy Inven- tions *
Light	Light & Shadows	Tin Can Alley 1. Shade vs. Sun 2. Colors *	Absorption *	Paper Mittens *
Light	Optics	Prism *	Spectrum *	Spectrum Colors for Plants *
Light	Optics	Bend the Light *	Parabola *	Parabolic Cooker*
Light	Daytime Astronomy	Tilt *	Absorption Angles*	Solar Collector *
Heat	Ice Cubes	1. Colored Ice Cubes 2. Melt It On Paper 3. Tin Can Alley *	Absorption *	Color Effects *
Heat	Ice Cubes	Kit	Insulation *	1. Winter Home 2. Summer Home *
Heat	Heating & Cooling	Kit	Conduction *	Hot Potato *
Heat	Heating & Cooling	Keep It Warm 1. Kit Problem Card #7 2. "Which Material Stores Solar Energy the Best?"	Storage *	Solar Collector & Heat Storage *
Heat	Heating & Cooling	1. Kit Problem Cards 18-22. 2. "How Much Does a Bimetallic Strip Bend when it is Cooled?"	Expansion *	"How Can You Test Your Homemade Thermostat?"

*Newly written activities

ENERGY FORM: ELECTRICITY

<u>SOURCES</u>	<u>PROPERTIES</u>	<u>USES</u>	<u>CONVERSION SYSTEMS OR TECHNOLOGY</u>	<u>CONSERVATION</u>
chemical (5)	measured volts (3, 5)	heating & cooling (5)	batteries (1, 3, 5)	appropriate
mechanical	amps	light	generator	energy form &
nuclear	ohms	laser	photovoltaic	conversion
hydro	watts	incandescent (1, 3, 5)	power plants	technology for
sun	transmitted	5)	nuclear	particular
lightning	conducted (1, 3, 5)	fluorescent	hydro	uses (5)
light	circuits (1)	magnetism (5)	fossil fuel	amount of elec-
	parallel & series	medical	heat & cool (5)	tricity used
	magnetic field (5)	stimulus	stoves, microwaves	
	controlled (3-5)	EEG, EKG	irons	
	stop & start	sound	refrigerators	
	converted (5)	work, motion (5)	air conditioner	
	stored (5)		fuses	
	predictable (3, 5)		circuit breakers	
	generated		(3, 5)	
	AC		light	
	DC (1, 3, 5)		light bulbs (1, 3, 5)	
			TV tubes	
			medical	
			EKG machines	
			magnetism	
			motors (5)	
			meters (5)	
			speakers & amplifiers	
			transformers	
			magnetic tape	
			computers	
			electromagnet (5)	

KEY: Batteries & Bulbs Unit 1, 3, and 5

UNIT: Batteries & Bulbs (Grade 1)

Electrical Energy

EXPLORATION:

The Batteries & Bulbs kit contains many activities which enable the students to begin to form an operational definition of electrical energy. They begin to define electrical energy by discovering that it can be transmitted or conducted, it travels in a circle, it can come from a battery, it can light a light bulb, and so on.

LABEL:

After students have explored the Batteries & Bulbs kit activities relating to an operational definition of electrical energy, the time is appropriate for the teacher to provide the concept label "ELECTRICAL ENERGY." This could be preceded by class discussion of experiences, an experience chart or pictorial records relating their findings. It is important for the teacher to be listening for student cue words which mean the same as the concept label during these activities. Primary students may be using the term "electricity" or "power" as they do their activities. Reinforce the students' words, but also introduce the concept label "ELECTRICAL ENERGY." For example, the teacher may say "another word for 'power' or 'electricity' is 'ELECTRICAL ENERGY'." Another technique is to use films, filmstrips, tapes, or books to label the concept.

APPLICATION: Let's Use It

1. What things use electrical energy?
2. Which of these things produce electrical energy in a way that I can feel?, see?, hear?, make things move?

PROCEDURE:

1. Students can form a list of things that use electrical energy. The list might be in the form of magazine and catalog pictures or student drawings. A bulletin board or flannelgraph could be an efficient tool to hold the pictures to allow for the next grouping activity.
2. Students can group the pictures according to their senses. For example, I can feel electrical energy through a toaster, hair

dryer and stove (heat). I can see electrical energy with a lamp or a flashlight (light). I can hear a doorbell, an organ or a radio (sound).

Students may initially group mechanical items (such as battery operated toys, electric trains and fans) under things to see. If so, then ask them to find all the items that use electrical energy to make things move.

UNIT: Batteries and Bulbs

Convert

EXPLORATION: Part I

Refer to Batteries & Bulbs Activity "Beginning Circuits", "Wires - Long & Short, Thick & Thin" and "Making a Bulb." Activity: Red Devil Motor.

EXPLORATION: Part II

"Red Devil" Motor.

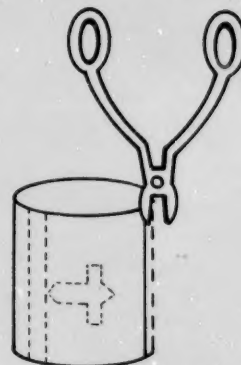
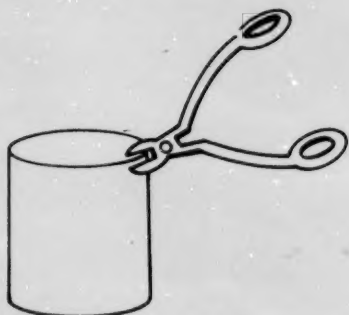
Initial question: How can we change electrical energy to motion?

- Materials:
- 1 No. 2 1/2 can open at both ends
 - 2 templates included with this activity
 - 1 8" thick copper wire uninsulated single strand (a single strand from a braided wire works well)
 - 4 dry cell batteries - "D" size
 - 1 4 x 5 x 1" pine board
 - 2 3 1/2" nails
 - 2 pieces insulated copper bell wire - 7 feet
 - 1 1/4" wood screw
 - 3 brads 3/4"
 - 1 hammer
 - 1 tin shears

PROCEDURE:

After removing the top and bottom from a clean No. 2 1/2 can, cut through the seam and lay the can out flat. Cut off the ridge along the top and bottom edges. Lay out the templates and mark the patterns with a felt tip pen. Cut out the two patterns.

templates (2) on a separate sheet.

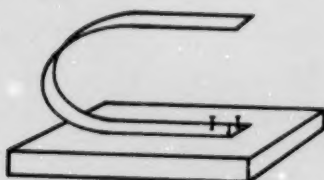


lay can out flat and trace templates

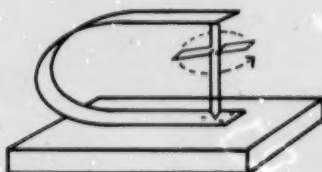
Use one of the nails and hammer to indent two small dimples on the metal strip as marked on the template. Use the nail and hammer to punch the three small holes in the metal strip as marked on the template.

Remove any paint or paper from both sides of the metal strip for a distance of 3 cm from the end with the three holes.

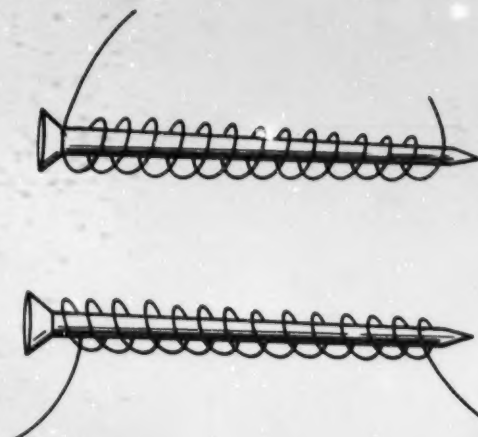
Mount the metal strip on the pine board using the three brads through the small holes.



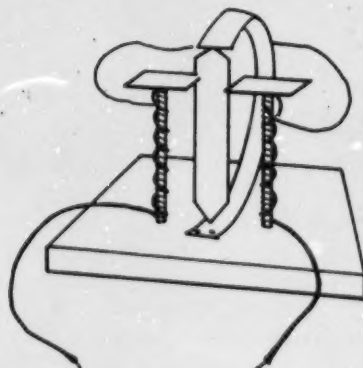
Bend the "arms" of the rotor at right angles to the shaft. Insert the rotor into the dimples in the metal strip and adjust the tension so the rotor turns freely.



Using one seven foot length of wire, wrap one nail to make an electromagnet. The nails must be wrapped in the opposite directions. Start by leaving seven inches of wire extending from the head of the nail and wrap the wire so that you are coming toward yourself as you wrap over the nail. Apply two tight layers of wire over the nail and then a more open layer from nail head to near the point. Leave seven inches of wire extending from the head of the second nail and wrap the wire so that you are going away from yourself as you go over the nail. Apply two tight layers and one loose layer. Leave ten inches extending after wrapping.

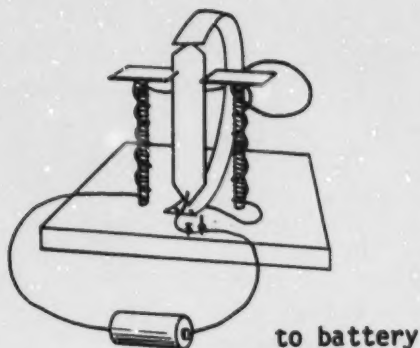


With the rotor in place and "arms" perpendicular to the long metal strip, mark the positions for the electromagnets. These electromagnets must be placed under the arms. Remove the rotor and pound in the nail electromagnets.



Remove 1/2" of insulation from the ends of all the wires. Attach the wires from the nail heads end of the electromagnets together. Attach the wire from the bottom of one nail to the metal strip. This can be done by pushing it tightly under the base of the strip. Attach the other wire from the nail electromagnet to the battery. Mount the screw in front of the rotor. Wrap the thin copper wire

(brush) around this screw with about 1 1/2" of the wire extended toward the rotor. Attach the other end of this wire to the other end of the battery.



Adjust the brush (thin copper wire) so that it just touches the side of the rotor when the rotor "arms" are parallel with metal strip. (That is not over the electromagnets.) If the touch is just right the rotor will spin rapidly. It may be necessary to spin the rotor to make the motor begin.

FURTHER QUESTIONS TO EXPLORE:

How does varying the number of batteries affect the rotor? How does arranging the batteries in series affect the speed of the rotor? How does arranging the batteries in parallel affect the speed of the rotor? Where should you place the brush to get the most speed? How does increasing the number of batteries affect the temperature of the electromagnets?

LABEL:

Students have explored materials and activities related to motors in Batteries & Bulbs. The time is now appropriate for the teacher to provide the concept label "CONVERT." It is important for the teacher to be listening for students' cue words which mean the same as the concept label during these activities. For example: the student may say "the electricity changes," "the electricity makes" or "the electricity turns into." Reinforce the students cue words but introduce the concept label "CONVERT" with it. For example: the teacher may say "another word for 'changes' or 'turns into' is 'CONVERT'." You need to do this to achieve ownership for both the concept and the label. Another technique is to use films, filmstrips, tapes, or books to label the concept.

APPLICATION:

This activity will help students apply the concept "CONVERT" to the electrical appliances in their home. They will then be asked to create new inventions converting solar energy.

Application question:

What things in your home convert electrical energy to a different form?

Materials: paper
pencil
assorted junk materials for model building

PROCEDURE:

Make a chart that will help identify what inventions we can design.

*Example of a chart partially completed:

1.		HEAT	SOUND	HEAT MECHANICAL	LIGHT	SOUND
2.	Electrical	Toaster	Stereo	Iron	Washer	Lamp Doorbell
3.	Solar					

Leave top line empty and begin on second line by listing the word "electrical" followed by all the examples of electrical appliances. Students should then label on the top line the energy form to which the electricity was converted.

Add the word solar on the third line. Ask the children to think of an invention that will convert solar energy to heat as in a toaster. How can I convert solar energy to sound as in a stereo? etc.

Students may sketch and/or build models of their inventions. Encourage students to use original titles for their inventions. Their sketches may be displayed as a giant matrix on a bulletin board.

ENERGY FORM: LIGHT

<u>SOURCES</u>	<u>PROPERTIES</u>	<u>USE</u>	<u>CONVERSION SYSTEMS OR TECHNOLOGY</u>	<u>CONSERVATION</u>
bioluminescence	paths (DA, O)	heat (O, DA)	photovoltaic cells	comfort level
sun and stars (DA, LS)	bounces (O)	plant growth (GS, LP&B, SFS)	electrical	
lightning	colors mixing (O)	medical treatment	radiometer	
combustion of	bends (O)	electricity	mechanical	
fossil fuels	waves (O)	chemical processes	photosynthesis	
light bulbs	angles (DA, LS, O)	photography	chemical	
arc lights	speed	bleaching	solar technology (O, DA)	
lasers	reflection (O)	sight	heating & cooling	
	refraction (O)	holography	ruby crystal	
	absorption (LS, DA)		light meter	
	diffraction (LS, O)		ozalid	
	opaque (LS)		holography	
	translucent (LS)		lens (O)	
	transparent (LS)		camera & photographic	
	focus (O, DA)		film & photographic	
	shadows (DA, LS, O)		paper	
	interference		mirrors (O)	
	atmosphere			
	colors (O)			
	rays (DA, O)			
	radiation (DA)			
	intensity (LS, O)			

KEY: Growing Seeds (GS)
Life of Peas & Beans (LP&B)
Starting from Seeds (SFS)
Daytime Astronomy (DA)
Optics (O)
Lights & Shadows (LS)

UNIT: Light & Shadows

Absorption

EXPLORATION: Tin Can Alley Part I Shade vs. Sun

What effects do shade and full sun have on the temperature of the air within tin cans?

Materials: 2 tin cans of equal size, shape and color
2 thermometers (can be uncalibrated)
2 cardboard disks the same diameter as the top of the tin can
2 small rubber bands
masking tape

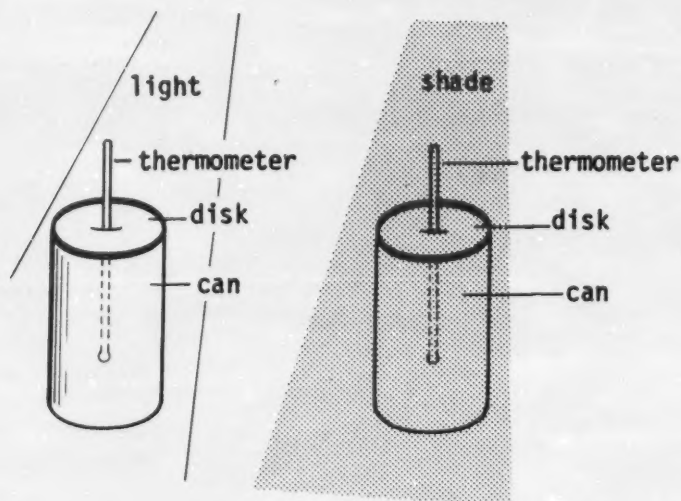
PROCEDURE:

Cover each of the cans with the cardboard disk. Cut a small slit in the center of the disk and insert a thermometer. (Note: more accurate comparisons will be achieved if the thermometers are positioned at equal depths in the cans.)

Students can choose a sunny site and a shady site. Referring back to sites they used in the Light and Shadows Unit can help them make their site selections.

Place one can in the shady site and the other can in the sunny site for equal amounts of time.

Wrap a rubber band around each thermometer to permanently record the height of the red line. The thermometers can then be set along a base line or fastened to a bulletin board for further class discussion.



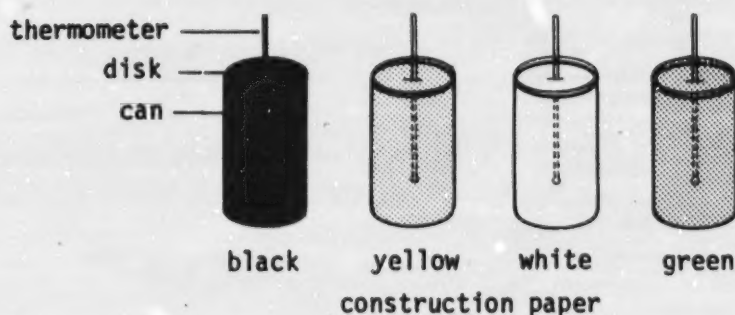
EXPLORATION: Part II Colors

What effects do different colored surfaces have on the temperature of the air within tin cans?

Materials: 4 tin cans of equal size and shape
4 thermometers (can be uncalibrated)
4 cardboard disks the same diameter as the top of the tin can
4 colors of construction paper (suggest black, white, green, yellow)
4 small rubber bands
masking tape

Procedure:

Cover each can with a different color of construction paper. Also cover a cardboard disk to match each can. Cut a small slit in the center of the disk and insert a thermometer. Place the cans with thermometers in a sunny place for equal amounts of time.



Wrap a rubber band around each thermometer to record the amount of heat in the same way as described in EXPLORATION: Part I.

LABEL:

The exploration activities relate to the concept of absorption. After exploring Lights and Shadows and Tin Can Alley, it is an appropriate time for the teacher to provide the concept label "ABSORPTION." This could be preceded by class discussion of experiences, an experience chart or pictorial records relating their findings. During these activities, it is important for the teacher to be listening for students' cue words which mean the same as the concept label "ABSORPTION". For example: the students may say "soaks up," "heats up," "gets hotter," "holds in." Reinforce the students' cue words while also introducing the concept label "ABSORPTION." For example, the teacher may say, "another word for 'heats up' is 'ABSORPTION'." This has to be done to achieve ownership for both the concept and the label. Another technique

is to use films, filmstrips, tapes, or books to label the concept.

APPLICATION: Paper Mittens

What effect do different colors of clothing have on our body's absorption of heat?

Materials: black and white construction paper
tape or stapler

PROCEDURE:

Make a white mitten for one hand and a black mitten for the other hand by tracing around your hand, allowing extra space all around for stapling or taping.

Cut out two white mitten shapes and fasten together. Cut out two black mitten shapes to make the other mitten.

Wear your mittens outside and hold them in the sunshine. How does each hand feel? Which mitten absorbed the most heat?



white



black

FURTHER QUESTIONS TO EXPLORE:

Which colors of clothing would you wear in the winter? in the summer?

What colors would you like your car seat to be on a hot summer day?
on a cold winter day?

What color would you like the roof of your house to be? Give reasons for your answer.

UNIT: Optics

Spectrum

EXPLORATION: Prisms

As background for the Prisms Activity refer to the Optics Unit, Section IV, Colored Light: Colored Light Mixing. As children explore and begin to analyze their color mixing, it would be useful to pose the following problems:

Can you make white light?

This white light problem helps to make a bridge from the spectrum to the understanding that white light is actually made up of the spectrum colors. This understanding is increased in the following activity by separating white light into the spectrum through one prism and recombining the spectrum to form white light by using a magnifying glass.

Material: 1 prism
white construction paper
1 magnifying glass

See what you can do with light shining through a prism. Direct the light through the prism onto the white construction paper. Can you find:

Red	Orange	Yellow	Green	Blue	Indigo	Violet
R	O	Y	G	B	I	V

Get a magnifying glass. Can you turn ROY G BIV into white light again using the lens?

LABEL:

Students explored materials and activities related to the spectrum. The time is now appropriate for the teacher to provide the concept label "SPECTRUM". This could be preceded by class discussion of experiences, an experience chart or pictorial records relating students' findings. It is important for the teacher to be listening for student cue words which mean the same as the concept label. For example: children may say "divides into different colors" or makes

"lots of colors." Reinforce the cue words and introduce the concept label "SPECTRUM" with them. For example: the teacher may say "another word for 'lots of colors' is 'SPECTRUM'." You need to do this to achieve ownership for both the concept and the label. Another technique is to use films, filmstrips, tapes, books to label the concept.

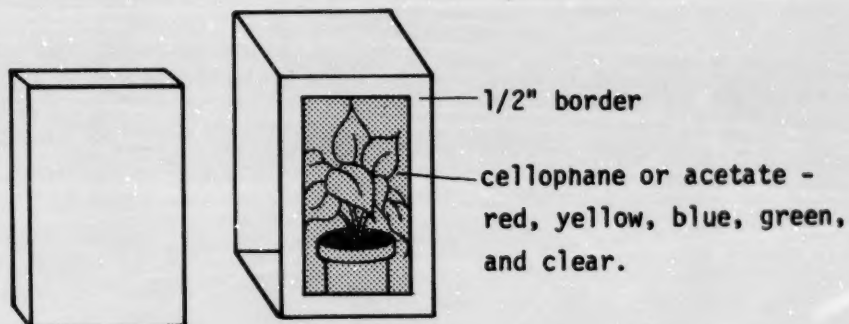
APPLICATION: Spectrum Colors for Plants

What effect do different parts of the light spectrum have on the growth of a plant?

Materials: 5 pea or bean plants
5 shoe boxes with lids
scissors
tape
measuring tape
red, yellow, blue, green and clear cellophane or acetate tape

PROCEDURE:

Cut out the side of each of the five shoe boxes leaving a 1/2 inch border around the edge. Tape a different color cellophane on each box.



Place the box on its end so the cellophane faces a light source and the lid is easily removed for watering.

Place all containers with plants inside where they can get equal amounts of sunlight.

When you water your plants remove the shoe box lid so that plants do not get direct sunlight. Replace lid.

Which color light allows the best plant growth? How do the single colors compare to the clear, direct light? height? color of plant? size of leaves? etc.

FURTHER QUESTIONS TO EXPLORE:

You may want to try shoe boxes with mixed colors. For example:
red on top of blues; or green and yellow, etc.

UNIT: Optics

Parabola

EXPLORATION: Bounce the Light

The purpose of this activity is to demonstrate how a parabola focuses light rays.

Materials: Meter stick
Graph paper, 24" x 20" - with 1" squares
Mylar reflective foil - or aluminum foil
Box with lid - ditto paper box works well
Masking tape
Oak tag

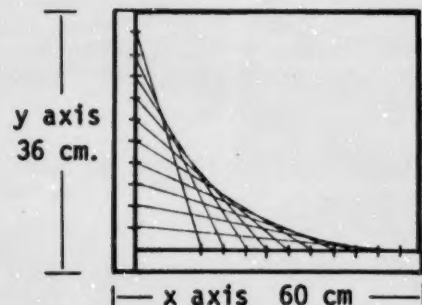
Procedure:

Part I Making the parabolic curve

Draw an "x" axis exactly 60 cm long the long way on the graph paper.

Draw the "y" axis exactly 36 cm long the short way on the graph paper.

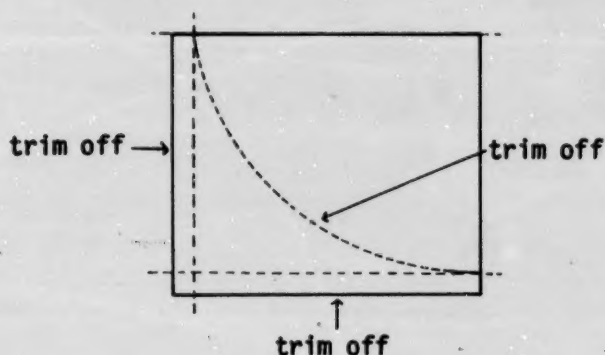
Mark the pairs of points - one on the "x" and one on the "y" axis and join the pairs with a straight line. Complete all pairs and lines and you will have constructed a parabolic curve.



All measurements are in centimeters:

"x"	30	31	32	33	34	35	36	37	38	39
"y"	36	35.9	35.8	35.7	35.4	35.0	34.6	34.1	33.5	32.8
"x"	40	41	42	43	44	45	46	47	48	49
"y"	32.0	31.2	30.3	29.3	28.2	27.0	25.8	24.5	23.1	21.6
"x"	50	51	52	53	54	55	56	57	58	59
"y"	20	18.4	16.7	14.9	13.0	11.0	9.0	6.9	4.7	2.4

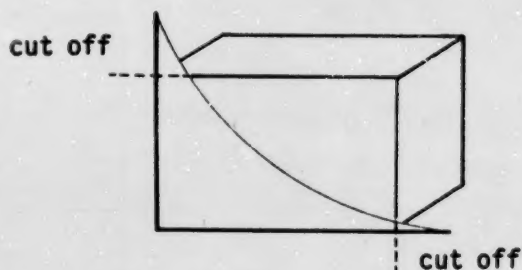
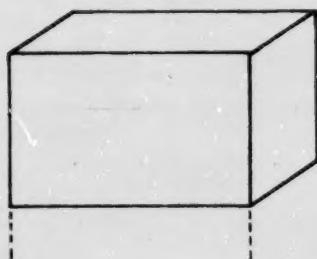
Cut along the parabolic curve and trim off any excess so that you have only the x and y axis and the curve.



Part II Making the curve fit in the box

Measure the inside length of the long side of the box. Measure this same length along the x axis and cut off. (see diagram)

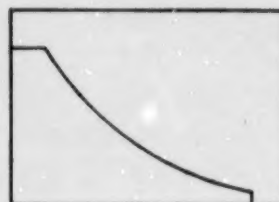
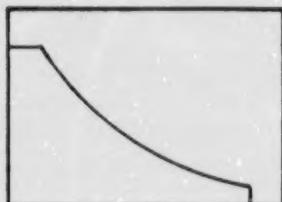
Place the curve in the box, x axis along the bottom of the box along the long side. Make the point on the "y" axis which is the top of the box, cut off any of the curve that would stick out of the box.



Remove the curve and use it as a pattern to make three curves of cardboard. The curves should be glued in the box one on

each side of the box against the inside walls and one glued in the middle.

Cut a piece of oak tag as wide as the box and lay it on top of the curves. Cut it so it will fit the curves perfectly. Apply the mylar foil to this oak tag and glue the oak tag on to the curves -- foil side up.

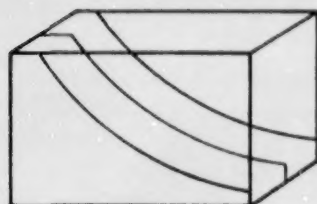


use pattern
& make
3 cardboard
designs

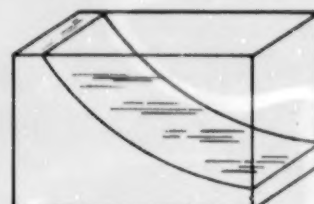


top view

side view

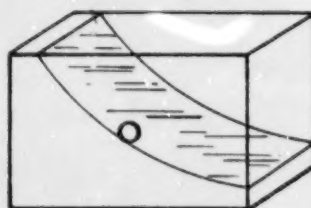


oak tag
with
mylar foil



Part III Cut the peek hole

Follow the parabolic curve down the inside of the box along the long side. Approximately half way down the curve cut a 1" diameter peek hole into the long side of the box. This peek hole will allow you to watch the rays of light entering the box and striking the curve.



cut peek hole on side of box

Part IV Punching the light ray holes in the lid.

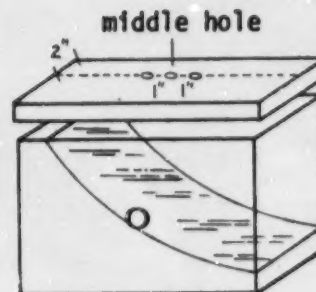
Draw a line the long way on the box lid. 2" in from the edge.

Find the center of the line and punch a hole with a sharp round pencil.

Along the line measure 1" to the right of the center hole and punch a second hole.

Along the line measure 1" to the left of the center hole and punch a third hole.

Place the lid on the box so that the three light ray holes are near the opposite side of the box from the peek hole.



Part V Viewing the light rays

Take the completed box into the sunlight. Point the three holes at the sun, look into the peek hole and move the box around so that you can follow the light rays as they enter the three holes and strike the parabolic curve.

Move the box around until the light rays form a small lighted circle on the end of the box. If the inside of the box is white it is easier to see the circle of light. A piece of white construction paper can be taped in the box to improve viewing.

Additional activities --

Additional holes may be punched along the line to increase the number of light rays--spacing them 1" apart is suggested.

Additional lines of holes may also be tried. These lines should be parallel to the original line.

This is the basic design of a solar cooker. Each line of holes would concentrate the sun's energy along the "hot dog".

UNIT: Daytime Astronomy

Absorption Angles

EXPLORATION: Tilt

What effect does the angle at which the light rays strike the surface of materials have on the temperature of the material?

Materials: black construction paper mounted on cardboard thermometers

PROCEDURE:

Place flat surface of construction paper perpendicular to the sun's rays and another flat surface of construction paper not perpendicular to the sun's rays. After ten minutes, check the temperature of the surfaces by placing a thermometer with bulb touching the paper.

FURTHER QUESTIONS TO EXPLORE:

What predictions can you make using different angles?

What differences occur when different colors of paper are used?

What differences occur when experiments are repeated at different times during the day?

What do you predict will happen when construction paper is placed with the edge to the sun's rays?

LABEL:

After exploring materials and activities related to correlating temperature with angle of exposure of material to the sun, the time is appropriate for the teacher to provide the concept label "ABSORPTION ANGLES." This could be preceded by a class discussion of experiences, an experience chart, or pictorial records relating their findings. It is important during these activities for the teacher to be listening for students' cue words which mean the same as the concept label "ABSORPTION ANGLES." For example: the student may say "tilt", "slant", "angle", "direction". Reinforce the students' cue words and label, but also introduce the concept label "ABSORPTION ANGLES." For example, the teacher may say "another word for 'slant' is 'absorption angle'." You need to do this to achieve ownership for both the concept and the

label. Another technique is to use films, filmstrips, tapes, or books to label the concept.

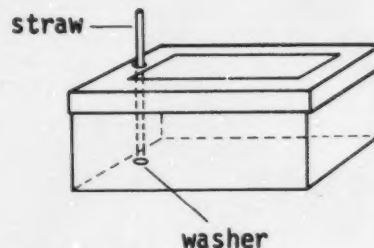
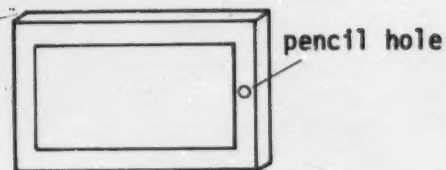
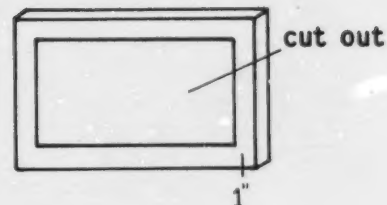
APPLICATION:

Make a Solar Collector

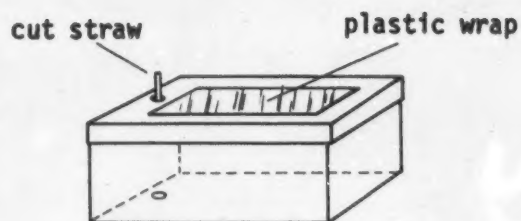
PROCEDURE: Part I Making the "window"

On the box lid:

1. Measure in 1" from the edge all the way around.
2. Cut along this line and remove the panel from the lid.
3. Using a sharp pencil poke a small hole in the border of the lid around the plastic wrap.
4. Push a straw through this hole and put the lid on the box. Push the straw until it touches the bottom of the box straight on--not at an angle.
5. Mark the spot where the straw touches the bottom of the box and glue the washer to that spot so that the straw would be in the hole in the center of the washer.
6. Pull straw back out. Cut the straw one inch long and tape in place in the hole in the lid.

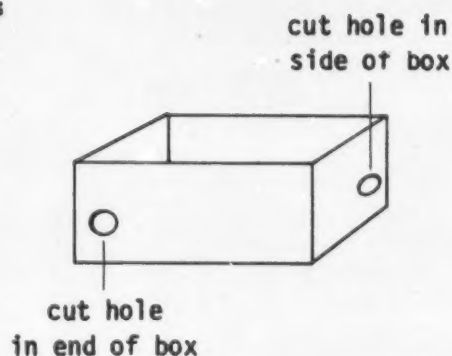


7. Cover the opening with clear plastic wrap.
8. Tape the plastic wrap in place.



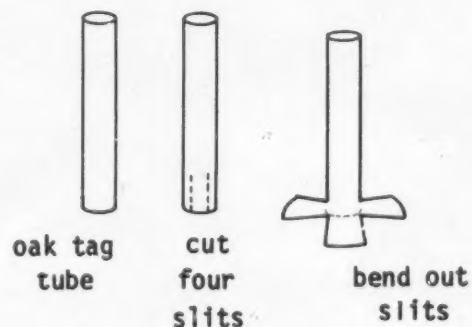
Part II Making the inlet and outlet vents

9. Cut a hole approximately 1 1/2" in diameter in the end of the box near the other end and near the bottom of the box. This is the inlet vent hole.
10. Cut a hole approximately 1 1/2" in diameter in the side of the box near the other end and near the lid. This is the outlet vent hole.

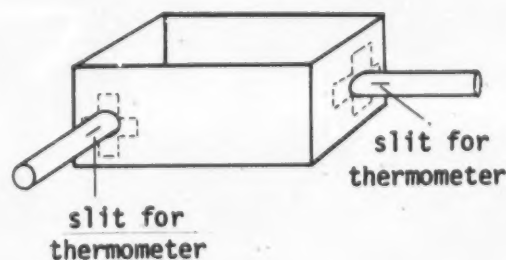


11. Using the oak tag make two tubes approximately 5" long and as large as the inlet and outlet holes.

- a. Tape the seam in the tube so it will be sealed.
- b. Using scissors cut four 1" slits around the end of the tubes and bend these flaps out.



- c. Push the tubes through the holes from the inside and tape the flaps in place.
- d. Cut a slit in each tube near the box--large enough to hold a thermometer.



12. The inside of the box can be sprayed black, painted black, or covered with black paper.

Part III Using the Solar Collector

The solar collector has a "theoretical ideal absorption angle." In theory this angle is perpendicular to the sun's rays--when the circle of light from the straw falls in the center of the washer. This theory doesn't take into account any reflected light from surrounding surfaces. In practice the ideal angle may be an angle that would capture the most available light. So, for example, an angle that captures light from a snow covered ground might be better than an angle directly at the sun--light reflected from a lake or pond might also be "best".

Have students experiment with different angles and determine their "best angle".

Record the temperature of the air in the input tube and the output tube.

Students may wish to change the color inside the box or they may wish to accordion pleat the paper to see the effect on the temperature.

ENERGY FORM: HEAT

<u>SOURCES</u>	<u>PROPERTIES</u>	<u>USES</u>	<u>CONVERSION SYSTEMS OR TECHNOLOGY</u>	<u>CONSERVATION</u>
nuclear	conduction (HC & IC)	human comfort	human comfort	insulation (IC)
chemical change	convection - wind	evaporation	conventional heating	utilization of
fuels	power (HC & IC)	condensation	& cooling systems	excess heat,
organic	radiation (IC)	heating & cooling	fireplaces	by-product
methane	layers in air (HC &	dry things	stoves	
body heat	IC) snow	food	furnaces	
combustion	soil	clothes	vents	
mechanical change	lakes	crops	air conditioning	
friction	reflected/absorbed	health purposes	humidifiers/dehumi-	
electrical	(IC)	cook	difiers	
sun (IC)	expansion/contrac-	sterilize	solar heating &	
	tion (HC & IC)	relax muscles	cooling systems	
		industrial purposes	dry things	
		metallurgical	dryers	
		pottery	clothes	
		paints	food	
		make electricity	hair	
		to make steam	crops	
		transportation	health purposes	
			sterilizers	
			cooking utensils	
			heated pools	
			sun lamps	
			heating pads	
			cauterizers	
			industrial	
			welding torch	
			kiln	
			smelting equipment	
			metallurgical equipment	
			steam turbines	
			combustion engines	

KEY: Ice Cubes (IC)
Heating & Cooling (HC)

UNIT: Ice Cubes

Absorption

The Ice Cube Unit has many exploratory activities which contribute to an understanding of heat energy. One such property is the ability of heat to be absorbed. The following Ice Cube activities deal directly with absorption, although the concept is not labeled as "ABSORPTION" at this time:

II. How can you make an ice cube melt faster than it does in the air?

IV. Who can keep an ice cube the longest?

The remaining activities in this unit explore further variables affecting the rate of absorption. The following EXPLORATION activities extend student experiences with absorption, particularly as it is affected by color.

EXPLORATION: Part I Colored Ice Cubes (see Insights in Ice Cubes Teacher Guide)

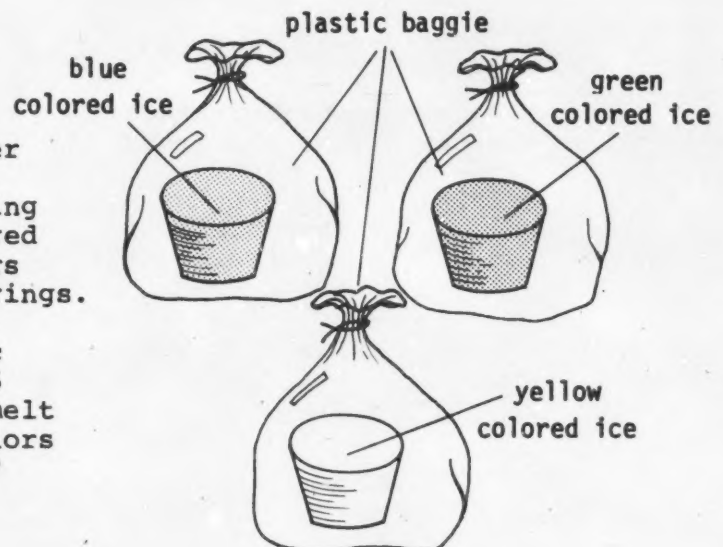
Will the color of an ice cube make a difference in how fast the ice cube melts?

Materials: food coloring - blue, yellow, red
plastic medicine cups
uniformly-sized colored ice cubes
plastic baggies
timer

PROCEDURE:

Put 20 cubic centimeters of water in each medicine cup. Add two drops of a different food coloring to each cup and freeze the colored water. A large variety of colors can be made by mixing food colorings.

Place each ice cube in a plastic baggie in direct sunlight for 15 minutes. Do all the ice cubes melt at the same rate? Do darker colors melt faster than lighter colors?



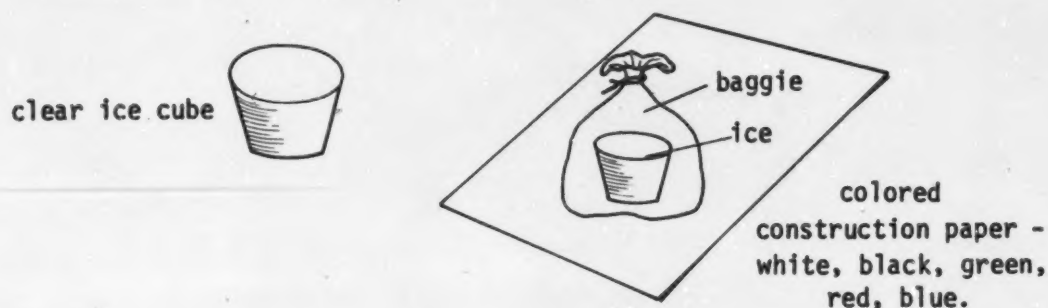
EXPLORATION: Part II Melt It On Paper

What effect does the color of paper have on the melting speed of an ice cube? Do ice cubes placed on darker colors melt faster than those placed on lighter colors?

Materials: white, black, green, red and blue construction paper
(all the same size)
plastic baggies
timer
uniformly-sized clear ice cubes in plastic baggies.

PROCEDURE:

Place an ice cube on top of each different colored sheet of construction paper. Which melts the most in 15 minutes?



FURTHER QUESTIONS TO EXPLORE:

Would you get the same results if the paper were on top of the ice cubes?

EXPLORATION: Part III Tin Can Alley

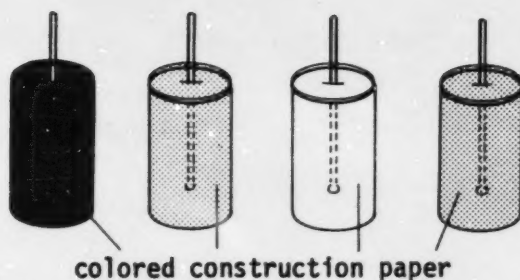
What effect do different colored surfaces have on the temperature of the air within tin cans?

Materials: 4 tin cans of equal size and shape with tops removed
4 thermometers
4 cardboard disks the same diameter as the top of the tin can
4 colors of construction paper (suggest: black, white, green, yellow)
masking tape

PROCEDURE:

Cover each with a different color of construction paper. Also cover a cardboard disk to match each can. Cut a small slit in the center of the disk and insert a thermometer.

Place the cans with thermometers in a sunny place for equal amount of time (suggest 20 minutes). Record your findings.



FURTHER QUESTIONS TO EXPLORE:

Wrap two cans with tin foil. Is there any difference in temperature if the shiny side is out or if the dull side is out?

Is there any difference in temperature if one can is painted with a full gloss coat and another is painted in a flat finish if they are both the same color?

What effect does a reflective surface have on the temperatures of the cans?

What effect does wind have?

LABEL:

Students have explored materials and activities related to absorption. The time is now appropriate for the teacher to provide the concept label "ABSORPTION." This could be preceded by a class discussion of experiences, an experience chart, or pictorial records relating their findings. It is important during these activities for the teacher to be listening for students' cue word which mean the same as the concept label "ABSORPTION." For example: the student may say, "take in heat" or "warms up." At this point, to make the transfer from ice cube experiences to the concept of absorption, it may be necessary to give the students some experience with the word "absorb." This could be done by asking the students to collect quickly one item in the room which might soak up water and bring it to the discussion area. Try out several of the items brought by children telling them that when the sponge, towel, etc. soaks up the water we say it "ABSORBS" the water. Returning to the ice cubes, reinforce the students' cue words--"take the heat", "warms up",--and introduce the concept label "ABSORPTION" with it. For example: The teacher may say, "Another word for the 'warming up' of the ice cubes is 'ABSORPTION'." This is necessary for the students to achieve ownership for both the concept and the label. Another technique is to use films, filmstrips, or books to label the concept.

APPLICATION: Color Effects

Would an attic with a white roof be cooler than an attic with a dark roof?

Would it cost more to air condition a house of a dark color or a light color?

List situations when dark colors and light colors affect you.

UNIT: Ice Cubes

Insulation

EXPLORATION:

The Ice Cube Unit has many exploratory activities which contribute to an understanding of heat energy. The insulating properties of various materials influence the movement of heat energy. The Ice Cube Activity IV - "Who can keep an ice cube the longest?" deals directly with insulation, although the concept is not labeled as "insulation" at this time.

LABEL:

After exploring the Ice Cube Activities, the time is appropriate for the teacher to provide the concept label "INSULATION." This could be preceded by class discussion of unit experiences, an experience chart or pictorial records relating their finds. It is important for the teacher during this time to be listening for students' cue words which mean the same as the concept label "INSULATION." For example, the students may say "heat stoppers," "the stuff that kept it cold," "the things that kept the heat away." Students might list all the materials they tried, and then apply one of their own labels (such as one of those mentioned above) to the total list.

Reinforce the students cue words and labels, but also introduce the concept label "INSULATION." For example, the teacher may say, "another word for these 'heat stoppers' is 'insulation'." This enables the student to achieve ownership for both the concept and the label. Another technique is to use films, filmstrips, tapes, or books to label the concept.

APPLICATION: Part I Winter Home

What effects do different kinds of insulation material have in heating and cooling your home?

Materials for each home:

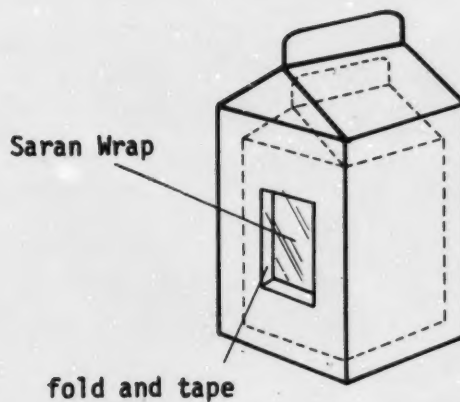
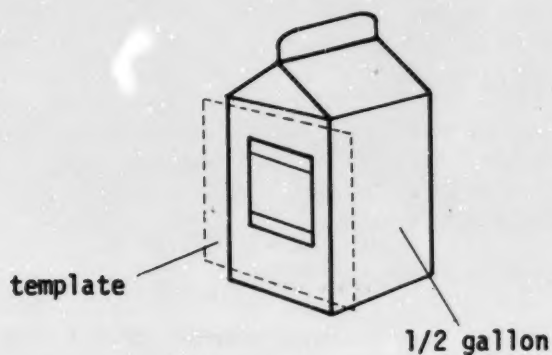
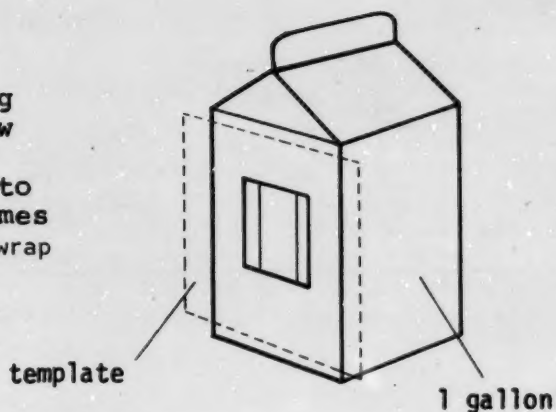
- 1 gallon milk carton
- 1 1/2 gallon milk carton
- ice cubes
- sand
- Saran Wrap
- plastic bag
- fiberglass
- sawdust
- thermometer
- razor blade

Materials continued:

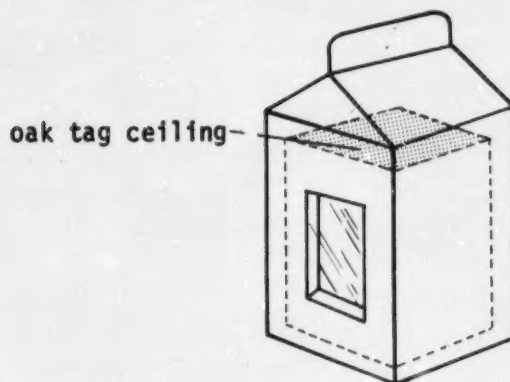
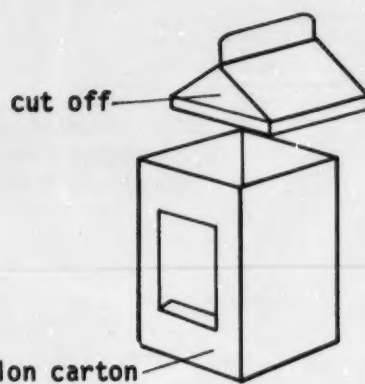
newspaper
masking tape
2 templates

PROCEDURE:

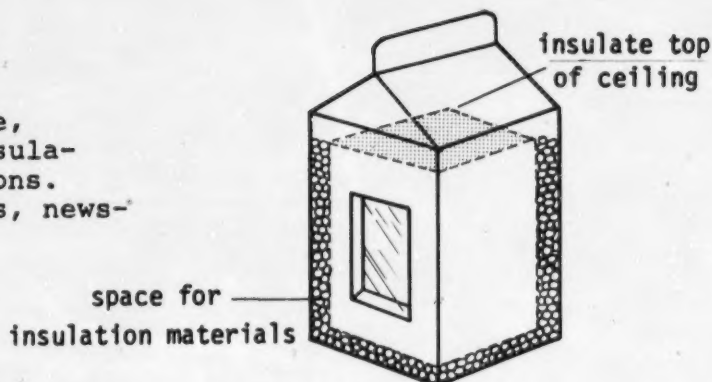
Take the two milk cartons and, using the templates provided, make a window in each. Place the smaller carton inside the larger and fold the tabs to form a window frame. Secure the frames using masking tape. Place the Saran wrap over the outside opening and using mystic tape secure it to the outside of the carton.



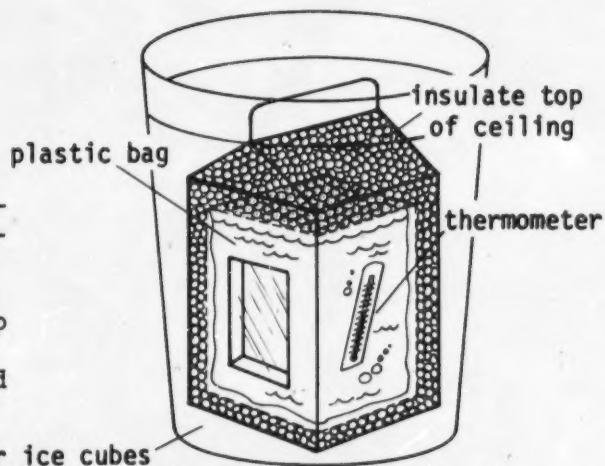
Cut the top off the inside carton one inch below the full line. Cut a piece of oak tag to fit on top of the inside milk carton to form a "ceiling." This ceiling should extend to the inside wall of the larger carton.



Make five homes. In each home, place a different kind of insulation in between the two cartons. Use sand, sawdust, fiberglass, newspaper, and empty walls.



In each house place a plastic bag inside the smaller carton. Place warm water in the bag. Place thermometer into water and note the temperature. Close bag around the thermometer and put the ceiling on and the insulation material over it. Close up the outside roof. Place house into 3 gallon bucket and place snow around it.



bucket of snow or ice cubes

Have the water temperature at the start the same for all houses. At the end of fifteen minutes, remove the plastic bag and note the temperature on the thermometer. Compare the before and after temperature for the various insulating materials.

APPLICATION: Part II Summer Home

A second activity would be to fill the plastic bag with cool water. Record the temperature. Place the house in a South facing window. After fifteen minutes, remove the plastic bag and note the temperature of the water. Which house had the coolest temperature? Why?

FURTHER QUESTIONS TO EXPLORE:

What difference in temperature would there be if the outside of the containers were colored? Do different colors have a different effect? Try black, white, blue, yellow or red?

How long an overhang on a house would you need to keep the sun from shining in during the summer and allow it to shine in the window in the fall and winter?

UNIT: Heating and Cooling

Conduction

EXPLORATION:

Refer to Heating and Cooling Kit Activity Cards 1-6

LABEL:

After exploring materials and activities related to conduction, the time is appropriate for the teacher to provide the concept label "CONDUCTION." This could be preceded by class discussion of experiences, and by an experience chart, or pictorial records relating their findings. It is important for the teacher to be listening for students' cue words which mean the same as the concept label during these activities. For example, the student may say "goes along" or "moves through" or "passes." Reinforce the student cue words and introduce the concept label "CONDUCTION" with them. For example: the teacher may say "another word for 'passes through' is 'CONDUCTION'." This enables the student to achieve ownership for both the concept and the label. Another technique is to use films, filmstrips, tapes, or books to label the concept.

APPLICATION: Hot Potato

What effect will a rod through a potato have on the speed at which it cooks?

Materials: 6 standard size baking potatoes
metal rod from Heating and Cooling Kit
oven set at 375°

PROCEDURE:

Place all the potatoes, three with rods and three without, in oven heated to 375°F.



6 baking potatoes



Remove two potatoes, one with a rod and one without a rod, after ten minutes. Cut the potatoes open. Which one is more done?

After 20 minutes remove two more potatoes and compare them.

After 30 minutes remove the last two potatoes. What effect did the rods have on heating the potatoes?

FURTHER QUESTIONS TO EXPLORE:

In what other ways do we use metals to conduct heat?

UNIT: Heating & Cooling

Storage

EXPLORATION: Part I Keep It Warm

The preliminary exploratory activity for this concept of heat storage occurs in the Heating & Cooling Unit Problem Card #7. Students discover the variance in the ability of different materials to store heat as they try to keep the heat from going to the end of the rod. This initial discovery can precede the next activity, which provides a more controlled measure of a materials' heat storage ability.

EXPLORATION: Part II

Science Activities in Energy -- Solar Energy Activity 11 -- "Which Material Stores Solar Energy the Best?" *

LABEL:

Students have explored materials and activities related to heat storage. It is now an appropriate time for the teacher to provide the concept label "STORAGE." This could be preceded by a class discussion of experiences, an experience chart or pictorial records relating their findings. It is important during these activities for the teacher to be listening for students' cue words which mean the same as the concept label "STORAGE." For example, the student may say "holds heat," "keeps it hot," or "stopped the heat." Reinforce the students' cue words but also introduce the concept label "STORAGE." For example, the teacher may say, "another word for 'keeps it warm' is 'heat STORAGE'." This is necessary for the students to achieve ownership for both the concept and the label. Another technique is to use films, filmstrips, tapes, or books to label the concept.

APPLICATION: Solar Collector and Heat Storage

Materials: 1 1/2 gallon milk carton
fiberglass
1 solar collector
thermometer
rocks
wire mesh
1 qt. milk carton

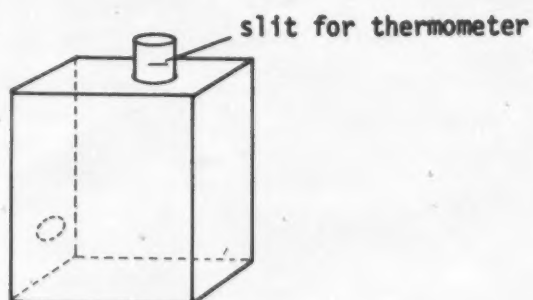
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(Directions for construction of a solar collector as written up in the extra activities for the Daytime Astronomy Unit)

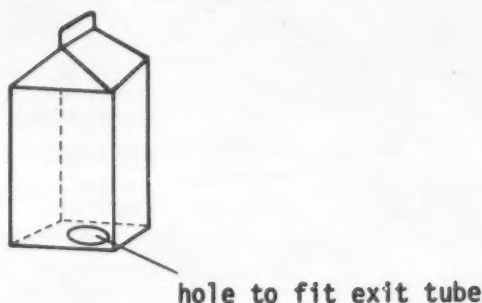
PROCEDURE:

In this activity we are going to use rocks to store the heat given off by the solar collector. The output vent of the solar collector will lead into the rock storage container, a one quart milk carton filled with rock.

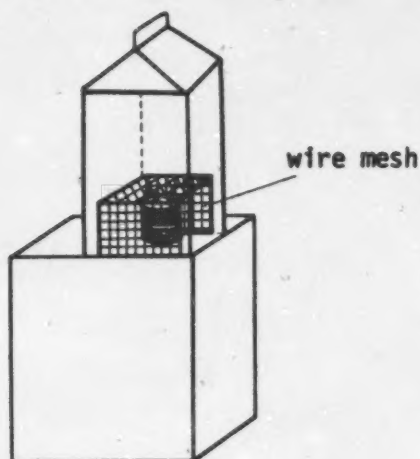
Step 1 -- Make a new exit tube to fit into the outlet vent on the solar collector. This exit tube should extend approximately 4 cm. beyond the vent. Cut a slit 1 cm. from the bottom. This is to hold a thermometer.



Step 2 -- Cut a hole in the bottom of the one quart milk carton to accept the new exit tube.



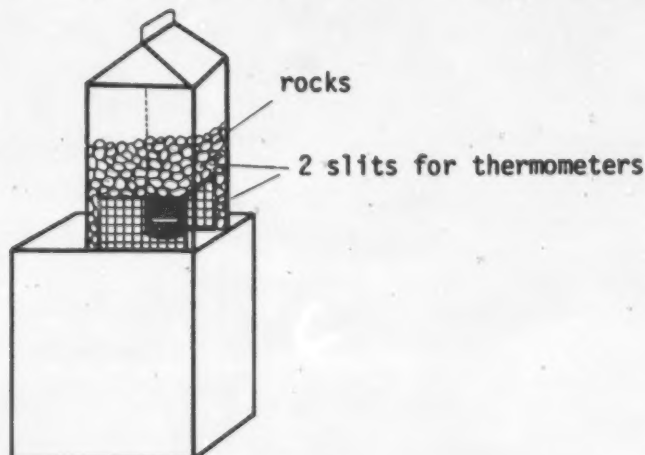
Step 3 -- Form the wire mesh so that it forms a bridge over the mouth of the exit tube and rests on the bottom of the milk carton. This bridge is to keep the rocks from crushing the tube and/or falling into the solar collector.



Step 4 -- Cut a slit in the milk carton 1 cm. from the bottom. Line this slit up with the one in the exit tube (step 1). Place the milk carton over the exit vent and insert a thermometer through both slits. This will record the temperature of the heated air.

Step 5 -- Carefully fill the milk carton with rock to a depth of 12 cm.

Step 6 -- Cut a slit in the milk carton just above the level of the rocks. Insert a thermometer through the slit and cover it carefully with rocks.



The solar collector and the heat storage unit can now be placed in the sun.

Records should be kept of the intake air temperature, exit air temperatures?

FURTHER QUESTIONS TO EXPLORE:

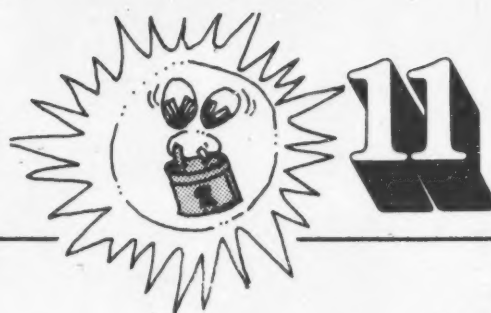
How does opening and closing the top of the milk carton affect the final temperatures?

What effect would insulating the storage area have on the final temperatures? (A 1/2 gallon milk carton with the bottom cut out and thermometer slits work well. Pack the space between milk cartons with insulating materials.)

How long can the rocks retain their heat?

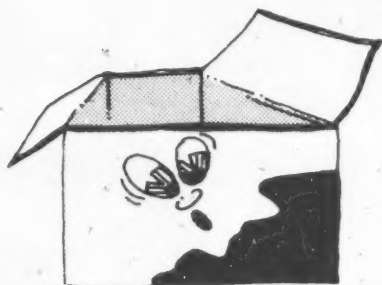
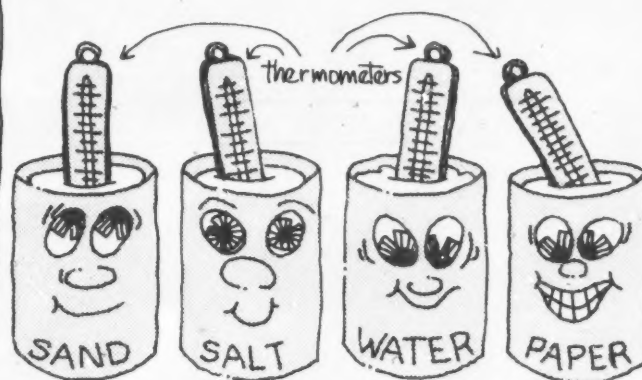
How could the heat from the rocks be used?

WHICH MATERIAL STORES SOLAR ENERGY THE BEST?



MATERIALS:

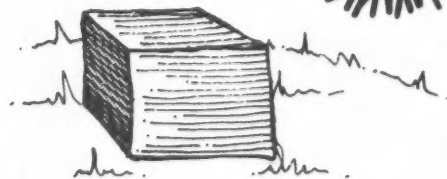
Cardboard box
Black paint
4 Small metal cans
4 Thermometers
Sand, salt, water, and
torn-up paper



Fill the cans and place a thermometer in each one.

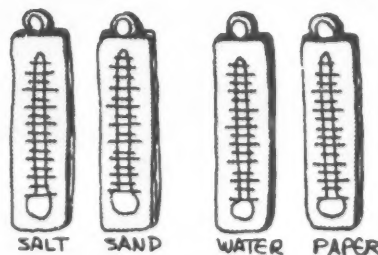
Paint the box black, and put the cans in the box.

Place the closed box in the sun for $\frac{1}{2}$ hour!



Now remove the cans and watch the temperatures fall. Stir occasionally.

Which temperature falls the slowest?



Which stores solar heat best?

UNIT: Heating and Cooling

Expansion

EXPLORATION:

Refer to ESS Heating and Cooling Expansion Service Problem Cards 18-22. Extend the problem cards with the attached Science Activities in Energy, Conservation Activity 3a -- "How Much Does a Bimetallic Strip Bend when it is Cooled?"*

LABEL:

The expansion concept label is utilized indirectly on problem cards 18 and 19 as it relates to the expansion frame. During the exploration activities children may use words which mean the same as the concept label. For example, the student may say "gets bigger." In this situation with the concept label included in the exploration activities, it may suffice to interchange the concept label "EXPANSION" and the children's terminology as you talk with them about their problem activity, checking to assure student ownership for both the concept and the label. You may wish to reinforce the concept label through films, filmstrips, tape, or books.

APPLICATION: Thermostat

Use the Science Activities in Energy, Conservation Activity 3b, "How Can You Test Your Homemade Thermostat?"*

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HOW MUCH DOES A BIMETALLIC STRIP BEND WHEN IT'S HEATED OR COOLED?

3a

MATERIALS:

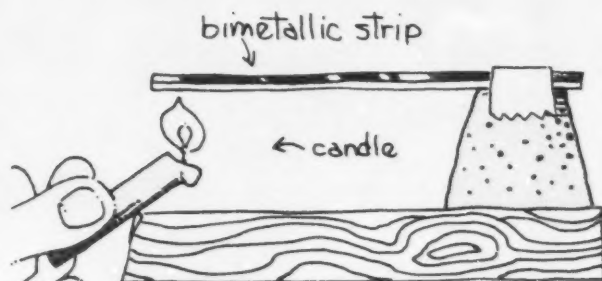
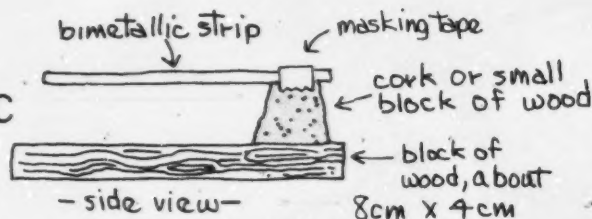
- 1 Piece of metal, 1cm or longer
- 1 Piece of bimetallic strip 4cm or longer
- Masking tape, glue, candle, ice cubes
- Large cork or small block of wood
- Piece of wood about 8cm x 4cm

Try a strip of aluminum pie plate!

A bimetallic strip is 2 different metals bonded together: for example, copper and iron.

Buy bimetallic strips from The Discovery Shop, American Museum of Atomic Energy. See buying instructions on folder!

Glue the cork or small wood block to the large one. Attach the bimetallic strip to the top of the cork with masking tape.

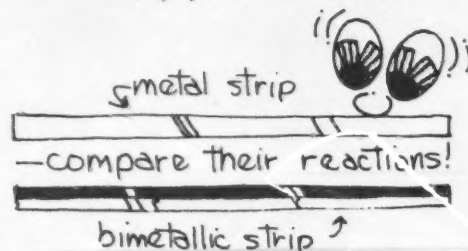


Test the bimetallic strip with a candle, then with an ice cube.

Place the candle under the end of the strip. What happens?

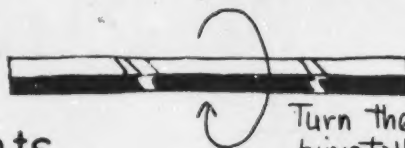
Remove the candle and put the ice cube in its place. What happens now?

Repeat both experiments using the metal strip. Does it react in the same way?



OTHER IDEAS TO EXPLORE:

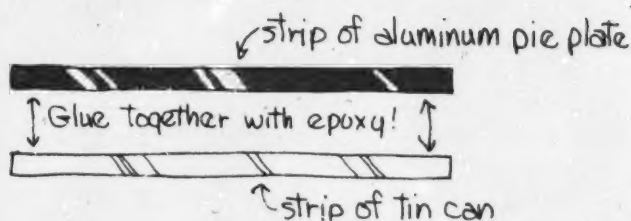
Turn the bimetallic strip over. Repeat the experiments.
Does the same thing happen?



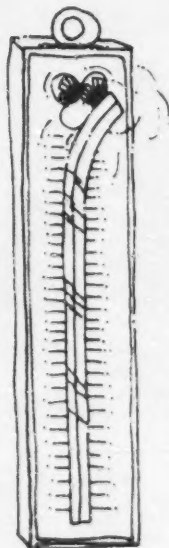
Turn the bimetallic strip over and try the experiment again!

Try making your own bimetallic strip.

Use epoxy glue to bond two different kinds of metal, such as a strip from an aluminum pie plate and one from a tin can.



Can you make a thermometer from your bimetallic strip?



HOW CAN
YOU

✓
TEST YOUR

3b

HOMEMADE THERMOSTAT ?

MATERIALS:

Bimetallic strip from Activity 3a
1 Flashlight battery
1 Flashlight bulb, 1 D cell
Copper connecting wire
Masking tape, finishing nail



Start with the gadget you made in activity 3a: use bimetallic strip.

Now hammer the nail to the end of the piece of wood under the free end of the bimetallic strip.

Wire like this:

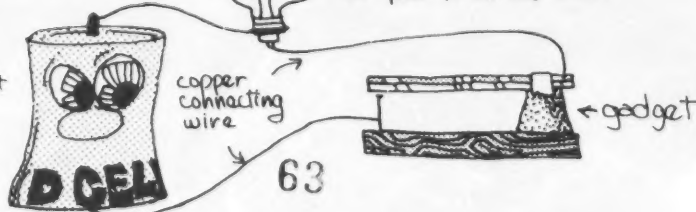


Push the bimetallic strip to the nail - the light should go on.

Make believe the lamp is a heater. Can you make the lamp go on automatically when you put ice on the bimetallic strip?

Make believe the lamp is an air conditioner. Can you make the lamp go on when you heat it gently or put it in the sun?

Can you adjust the height of the nail so that the lamp goes on when the temperature of the room reaches 21°C and goes off at 19°C ?



OTHER IDEAS TO EXPLORE:

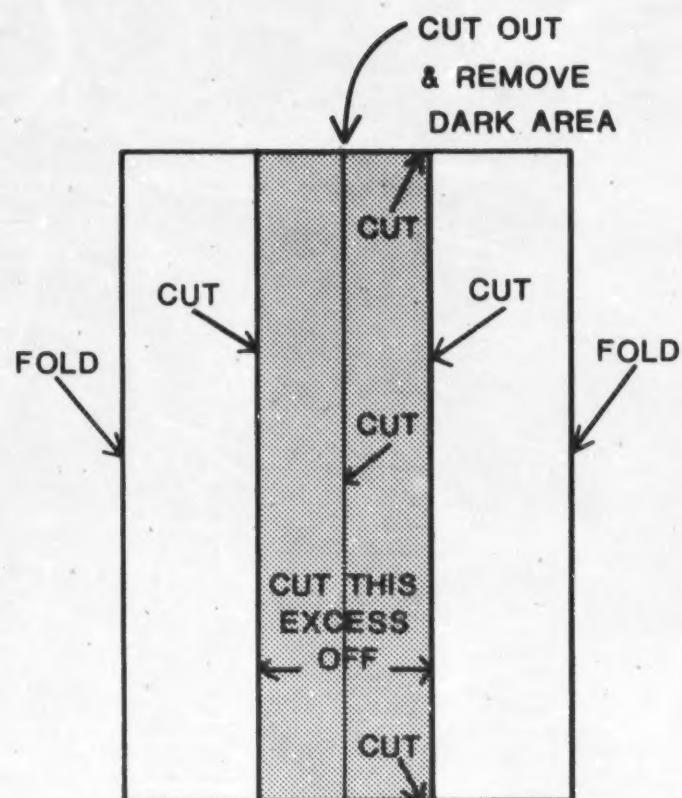
Look inside a blinking bulb as it flashes on and off. Notice the bimetallic strip that bends outward and switches the bulb off after it has heated up.



Can you find the bimetallic strip in a blinking bulb?

Look for ice cream bags that have one side made of paper and the other of aluminum foil. Would a strip of this material behave like a bimetallic strip?

ICE CUBES - INSULATION - TEMPLATE #1



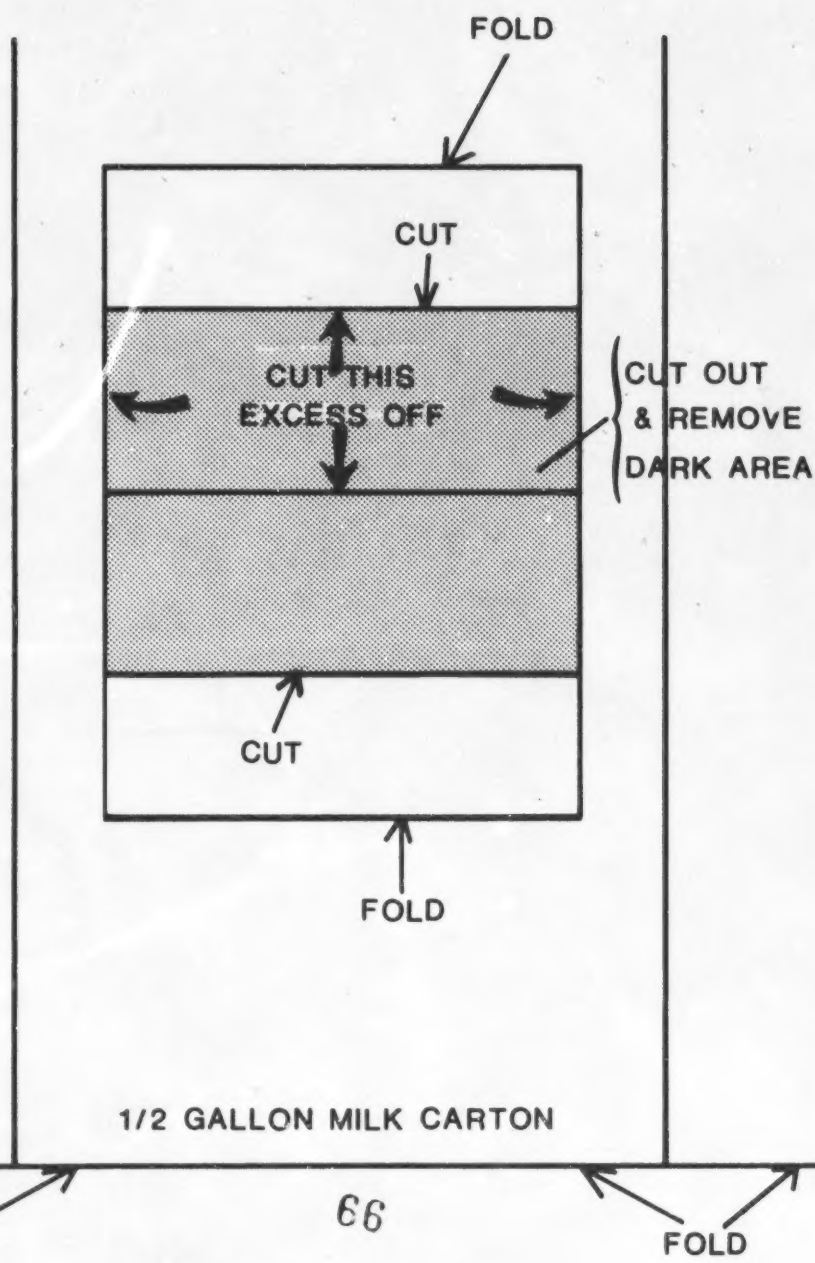
GALLON MILK CARTON

FOLD

BOTTOM
65

FOLD

ICE CUBES - INSULATION - TEMPLATE #2



— TEMPLATES —

